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NOVEMBER 25, 1878.

THE SURFACE GEOLOGY OF PHILADELPHIA AND VICINITY.

BY HENRY CARVILL LEWIS.

At intervals during the past year the writer has been devoting some attention to the gravels and clays of our city, and although the work as yet is only preliminary, and is still in progress, it is thought that a sketch of what has been done may serve to show what an interesting field is open for more thorough investigation. A large number of localities have been examined and many sections have been made, but it is proposed at present merely to summarize the facts observed.

The Upland Terrace.—1. A traveller going from the city upon the Germantown Railroad will notice in the cuttings for new streets between Tenth and Broad Streets, and in the railroad cut at New York Junction, numerous exposures of red or yellow gravel, often overlaid by clay. The brickyards in the vicinity of Nicetown expose large beds of brick-clay containing occasional well-rounded boulders and pebbles. The land so far has been comparatively level, and no rocks have been seen. Just before reaching Wayne Station, rocks rise upon both sides of the road, the clay and gravel disappear, and a rolling wooded country is entered. A thin covering of light micaceous soil containing no pebbles or boulders covers the gneissic rocks from here to Chestnut Hill. There is a great contrast between the two regions.

2. On the Pennsylvania Railroad it will be noticed that, soon after leaving the depot, gravel covers the rocks along the Schuylkill, and as the railroad turns back from the river, a plateau of clay follows. The Centennial grounds lie upon this clay, and boulders are frequent. Upon reaching Fifty-seventh Street, opposite Belmont and George's Hill, the hill is entered by a cut, the rocks come to the surface, and the drift is no more seen.

3. Again, on the North Pennsylvania Railroad gravels first appear, then, on higher ground, clay, and soon after passing Green Lane Station, the rocky uplands, free from drift.

4. So, too, on the West Chester Railroad, gravels and clays cover the ground up to the base of the hill on which Swarthmore College stands.

5. On the other hand, the New York division of the Pennsylvania Railroad and the Philadelphia, Wilmington and Baltimore

Railroad, which run parallel with the Delaware River, do not rise out of the region of drift.

Now, connecting by a line the four points mentioned, it will be found to represent a long straight hill 200 feet or more in height, having a northeast and southwest trend, parallel to the river, and lying at a mean distance from it of about four miles. We have traced it from Bucks County, through Philadelphia and Delaware Counties, into the State of Delaware, and find that it uniformly defines the western boundary of the drift. This hill is easily recognized where uncrossed by creeks, being remarkably straight and of uniform height. It forms the limit of tidewater, and is recognized where it crosses streams by the occurrence of rapids or falls. Being the first hill of importance west of the Delaware, it often commands a fine view and is a favorite site for residences. The geographical position of this ancient terrace may be more exactly defined in the vicinity of Philadelphia, as the hill which crosses Second Street Pike near Foxchase, and crossing Tacony Creek farther south, runs nearly parallel with it as far as Crescentville; which crosses Green Lane and New Second Street road near the place of Mr. J. L. Fisher; crosses the North Pennsylvania Railroad above Olney road, and the York road below the Jewish Hospital; which crosses Germantown Avenue at the railroad bridge (being here called Negley's Hill), and running along the railroad to beyond Wayne Station, passes back of the Germantown Cricket Ground, past Old Oaks Cemetery to Falls of Schuylkill. Thence, passing Chamouni, Belmont, and George's Hill, it crosses the Pennsylvania Railroad near Hestonville, and Haverford Road at Haddington; passes back of the Burd Orphan Asylum into Delaware County, and runs north of Kelleyville, Clifton and Morton to Swarthmore College, and thence past Village Green into Delaware.

This hill, which is approximately parallel not only to the river, but also to the shore of the Atlantic Ocean and to the line of strike of the Cretaceous formations of New Jersey, forms, as we have seen, the main dividing line between the ancient and the modern formations.

We shall call it for convenience the *Upland Terrace*. The strike of the gneiss forming it corresponds closely with the trend of the terrace itself. A boulder-bearing clay rests upon its southeastern slope at a uniform elevation of 150–170 feet above mean ocean-level. While it is true that, as will appear hereafter, there are

patches of an ancient gravel on high points back of it, the Upland Terrace nevertheless remains as the most important geological feature in southeastern Pennsylvania.

Between the Upland Terrace and the Delaware, clays and gravels cover the rocks in a continuous sheet except where eroded away in the neighborhood of streams. The amount of their erosion is in some respects a measure of the age of the surface formations. It has been noticed that these formations in the vicinity of Philadelphia have undergone very different amounts of erosion, the amount of such erosion increasing as we recede from the Delaware; and this fact is regarded as offering evidence that the deposits are of different ages; those lying farthest from the river and highest in elevation being the most ancient, and those which are close to the river, which have undergone but little erosion, being the most modern of our surface formations. Examples of erosion of the Philadelphia gravel may be well seen on the Philadelphia and West Chester Railroad which crosses a number of creeks and runs nearly parallel to the terrace for several miles. As each creek is approached the drift¹ disappears and rocks come to the surface. So on the Schuylkill, no gravel is seen on the river drive in the East Park, but upon going back from the river and rising 100 feet above it, as far as the East Park Reservoir, gravel appears abundantly. Yet on the same river, nearer the Delaware, a newer gravel, made of different materials, not only forms its banks but underlies it.

Recent Alluvium.—The most recent of all the surface deposits is the stiff bluish clay which covers the low ground in the southern part of the city. The Richmond meadows and the flats of Moyamensing, Greenwich and Tinicum are covered by this deposit. It is bounded by a low terrace which may be called "*The Floodplain Terrace.*" This terrace, up to which the river often comes in times of flood, crosses South Broad Street diagonally below Moyamensing Avenue, and crossing the Delaware extension of the Pennsylvania Railroad near Penrose Ferry Road, winds around Point Breeze Park back towards the Gas Works, and passing below Suffolk Park crosses into Delaware County. This terrace is about ten feet above mean tide. It is the lowest and newest of all the terraces and is formed of the next older formation, the "River gravel." The mud or clay lying between this terrace and

¹ The term "drift" here includes all superficial formations of whatever age.

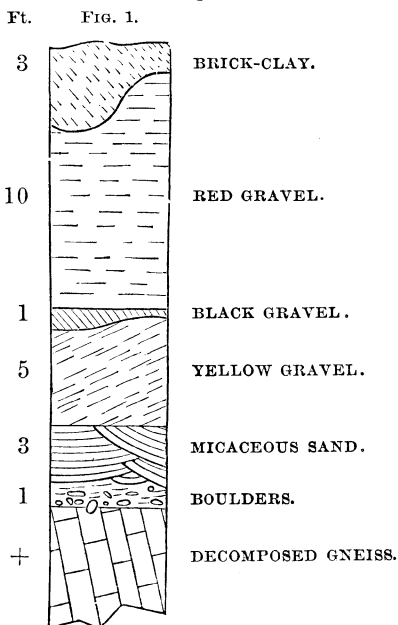
the river is too stiff to be useful for brickmaking. Blackened fragments of twigs, roots and leaves are frequent in it, and it is said that trunks of the white cedar abound in it in some places. There is here an indication that these beds are sinking and that, as on the Atlantic coast, the water is encroaching. Frequently a good peat covers the clay.

The River Gravel.—Forming the Floodplain Terrace and lying back of it, is a light sand and gravel free from clay, which may be designated the “River Gravel,” since it formed the ancient river bed. It is composed of a light micaceous sand made from the wear of gneissic rocks, overlying a clean, loose gravel, whose pebbles are composed of the rocks which form the river bottom farther north. The pebbles are generally flattened and are composed of gneiss, Triassic red shale, Triassic argillite, etc. It is of a gray color, white quartz pebbles being comparatively scarce. It underlies the river to a great depth and forms islands in it. Frequently large boulders lie upon the river gravel. Bridesburg and the Lazaretto are built upon it. The sand is used for building purposes. It is bounded by the “*River Gravel Terrace*,” a terrace rising some twenty feet above mean tide, and which is capped by the red gravel and brick-clay about to be described, while rocks are frequently exposed at its base. The Chester Branch of the Reading Railroad lies below this terrace, and the present line of the Philadelphia, Wilmington and Baltimore Railroad is above it.

The Red Gravel and Brick-Clays.—The built-up portion of the city stands upon an extensive deposit of brick-clay and gravel, sections of which are exposed in every cutting. The brick-clay invariably overlies the gravel, and will therefore be first described. By far the finest exposures of brick-clay are those on either side of Long Lane, in the “Neck.” The clay here is very compact, free from sand and gravel, and is often 15 feet or more in depth. Loam lies above it, and is mixed with it for brick-making. Well-rounded boulders of Potsdam, Medina, Trias, etc., are frequent. The whole lies upon some 20 feet of stratified gravel. It is a much finer and deeper clay than that of the northern part of the city, as at Nicetown. It is interesting to note that while the clay which is farthest from the Upland Terrace and lowest in elevation is purest and deepest, on the other hand that near the terrace and more than 100 feet above the river is both shallow and sandy. It suggests that the former was deposited in deep water and the latter near the shore. At the base of the terrace the clay is but

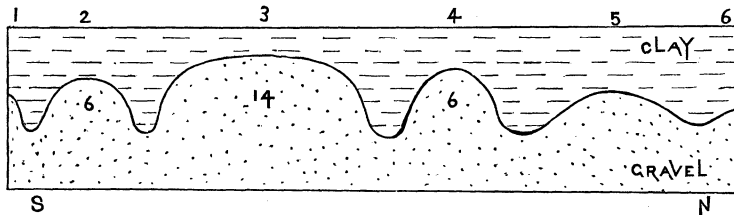
two or three feet deep. The boulders of the Nicetown clay are similar to those of the Neck clay, except in the fact that in the latter there are numerous rounded and sharp fragments of triassic red shale, while in the former boulders of that material are very scarce. The boulders of both clays are invariably derived from a northern source. No shells or organic remains have as yet been noticed in this formation.

Beneath the clay, and often unconformable with it, is the Philadelphia red gravel. It is a clayey gravel which packs well and is much used on roads, and whose red color is caused by the ferruginous clay in which the pebbles are imbedded. The pebbles are composed of all kinds of rock and are not flattened as are those in the river gravel. The predominant material is white quartz, but pebbles of all other materials, as conglomerate, sandstone, fossiliferous hornstone, flint, red shale, etc., are numerous. Stratification is observed in almost every section exposed. Good sections of gravel are seen near the University of Pennsylvania. It has here an elevation of about 50 feet, and comes to the surface of the ground with but a very slight covering of clay. The gravel is here over 15 feet deep, and as it is in some respects a typical exposure, a section is herewith presented.



It will be noticed, in the *first* place, that the clay lies in the form of crests and hollows upon the gravel. This is almost invariably the case. Beautiful examples of wave motion may be seen at Twenty-eighth Street and Columbia Avenue, at Tenth and Tioga, at Fifteenth and Clearfield Streets, and in Fairmount Park. In each of these we have apparently the action of a rushing flood of water upon the gravel. Often the clay lies in a kind of pot-hole in the gravel, and a concentric structure of clay and pebbles can be seen. The following section, at Twenty-eighth Street and Columbia Avenue, shows six well-marked waves of gravel and clay, the clay always filling the hollows between the crests of gravel.

FIG. 2.



The approximate dimensions of the waves are given in the diagram. Along the line of contact between clay and gravel there are alternate streaks of fine and coarse gravel.

A very beautiful example of water action is exposed at Fifteenth and Clearfield Streets, in a cut about 100 feet in length (Fig. 3).

The *second* point to be noticed in the section near the University is the stratification of the gravel, and its division into layers of three different colors,—red, black and yellow. It is instructive to note that this division is by no means a local one, but exists along a line of about equal elevation (60 to 80 feet above ocean level), in widely separated parts of the city. While the colors are of course due simply to different states of oxidation of the iron, the fact that they mark continuous deposits through long distances, indicates a uniformity in the condition of deposition which could be due only to the presence of a large body of water.

In the *third* place, the section (Fig. 1) shows the important fact that the gravel rests, not upon a hard floor of rock, as is usual with the drift in more northern States, but upon a completely decomposed gneiss. This is universally the case in every section examined in the vicinity of Philadelphia. In no case does the gravel rest upon

unaltered rock, except possibly in the vicinity of streams where the water has eroded away the soft rock. In such positions, however, the gravel also is usually eroded, except in the case of the "River gravel" proper. It will be observed that a sharp stratified micaceous sand, made up of the materials of the decomposed gneiss, and often showing "flow and plunge" structure, lies below the gravel. In the section given, a well-rounded boulder of a lower Silurian sandstone is seen partially imbedded in the decomposed gneiss. This fact offers two interesting deductions:—

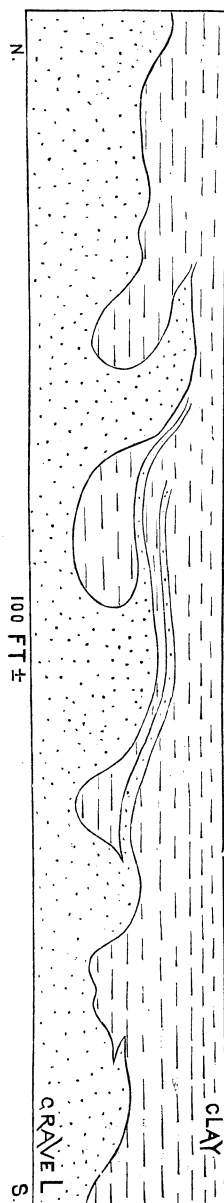
(1.) That the gneiss was decomposed before the deposition of the gravel.

(2.) That water, not ice, was the agent of such deposition.

(1.) As additional evidence in support of the first deduction, it has been observed in several sections that portions of the decomposed gneiss have been taken up and interstratified in horizontal layers, either with the gneissic sand, or with the gravel itself. That the steeply-dipping decomposed gneiss should be thus re-stratified, as though by a flood, and that, on the other hand, no such phenomena are ever observed in undoubted glaciated regions, can only be explained upon the assumption that the gneiss was decomposed before the Glacial epoch. That such decomposition took place in a yet earlier geological age, will be indicated below under a description of the "Bryn Mawr gravel."

(2.) Absence of a glacier in this region is indicated by the wave-like junction of gravel and clay, by the stratification of the gravel, and by the presence of decomposed gneiss. No polished surfaces of rock have

FIG. 3.



ever been observed in this region, although the occasional slickensides upon the gneiss in some quarries has been mistaken for glacial striæ. Frequently the lower yellow gravel is replaced by a yellow sand more or less fine, which is used for building purposes; and in this there are often good examples both of oblique lamination and of "flow and plunge;"—structures attributable to flowing water. Examples may be seen on the North Penna. R. R. and in the East Park. The boulders of both clay and gravel, if not brought down by water alone, have been dropped by floating ice. The absence of life in either deposit indicates that the water was too cold to support it.

The conclusion is therefore forced upon us that, during the melting of the great Northern Glacier, whose southern terminus crossed the river probably near Belvidere, the flooded Delaware, then a great torrent five or ten miles wide and at least 150 feet deeper than it is now, deposited at first gravels and afterwards, when quieter, clays; while floating ice carried down already rounded boulders and dropped them upon its bed.

The uniform elevation of the edge of the clay at the base of the Upland Terrace can hardly be accounted for upon another hypothesis.

The presence of an actual glacier over this region has, however, been brought forward as the only explanation of our surface deposits. Thus, in a recent paper,¹ the author, after inspection of a gravel opening in West Philadelphia, concludes "that this belt of drift deposit is no other than a glacial moraine formed by the Schuylkill glacier receding from the site of the city." He adds, "the surface of the gneiss where laid bare is comparatively smooth, and shows evidence of having been polished, though so soft as not to retain the marks of glaciation." To us the very locality described (Forty-fifth and Spruce) offers strong evidence of the absence of all glacial action. The gravel, containing no scratched pebbles, is horizontally stratified and shows flow and plunge structure; while the underlying decomposed gneiss, so far from being polished, is seen in several places to have been taken up by the swiftly flowing water and mingled with the gravel which it bore along, so that several layers of decomposed gneiss, each about half an inch in thickness, and soon dying out, alternate with the lower portion of the gravel.

¹ "On Glacial Deposits at W. Phila.," *Proc. Am. Phil. Soc.*, Nov, 1875.

It has been supposed that the bending over of the outcrops of steeply-dipping rocks, sometimes observed near Philadelphia, has been caused by the pressure of a glacier. A very beautiful example of such broken and bent-over strata is seen in a quarry at Edge Hill. That such phenomena are to be explained, not by glacial agencies, but by the force of gravity only,—being the gradual sliding-down-hill of the soil known as “creep,”—is shown by the facts, (1) that such bending over is always towards a lower elevation,—down hill; (2) that on the two slopes of the same hill the strata have been seen to be bent over in opposite directions. Thus at various points along the long ridge of altered Primal slates known as Edge Hill, the slates on one slope are bent towards the south, and on the other towards the north. A similar fact has been noticed in the gneiss forming the Upland Terrace. Moreover, such bending of the strata often occurs in regions quite free from drift.

If, as we have conjectured, the Delaware Valley was filled with a large body of water when the drift was deposited, it is reasonable to suppose that the Schuylkill also was of far greater size, and that some boulders would be brought down the valley of that stream. Here again facts sustain the hypothesis. In the gravel taken from the excavation for the East Park Reservoir, associated with Triassic red shale and other boulders, we have found partially worn fragments of chlorite slate containing octagonal crystals of magnetite, evidently derived from the steatite quarry at Lafayette, six miles above on the Schuylkill. At Twenty-eighth Street and Columbia Avenue is a large boulder of trap, identical with that of the trap-dyke which crosses the Schuylkill River at Conshohocken.

It thus appears that during the Glacial epoch the waters of the Schuylkill emptied into those of the Delaware at Falls of Schuylkill, the city proper being entirely submerged.

Before closing our account of the Philadelphia red gravel—the “University gravel,” as it might be called for distinction—it will be necessary to say a word as to what occurs on the New Jersey side of the river. If we are correct in ascribing this gravel and brick-clay to a flooded river valley, similar deposits at the same elevation must be found on both sides of the river. Although we have been able to do but very little work upon this point in that State, it has been observed: (1) That there is a sand at Camden near the river, similar to the sand of the “River gravel” of lower

Philadelphia ; (2) that at a higher elevation there are deposits of superficial yellow brick-clay quite distinct from the underlying plastic clays ; (3) that boulders identical with those on this side of the river occur in the brick-clay ; (4) that a stratified red gravel containing Triassic shale, and similar to the University gravel occurs ; and, (5) that there are indications of the existence of a Terrace, several miles from the river, bounding the brick-clay and its boulders, and composed of an older, and probably oceanic, gravel and sand.

The Fossiliferous Gravel.—There seems to be evidence that between the Upland Terrace and the River Gravel Terrace there is an intermediate terrace, back of which is a gravel somewhat different from the Philadelphia red gravel. It is characterized by comparative absence of Triassic red shale, and by the presence of numerous pebbles of flint, hornstone, or limestone, which are frequently fossiliferous. These pebbles, as well as those of white quartz, are not fresh-looking, but are eaten and weather-worn by age. In both its position and its appearance it is an older formation than the red gravel. It is of a yellowish color, becoming white when exposed to the weather, and is more sandy than the red gravel. For these reasons it is less esteemed for road-making. The Germantown Railroad cuts through this gravel at New York Junction. We have found here pebbles containing Cyathophylloid corals, Favosites, a Trilobite, etc. The Connecting Railroad at Ridge Avenue Station cuts through the same gravel, and here we have found *Strophomena*, etc. Other fossils have been found below the clay in the East Park and at the Centennial Grounds.

This gravel is found on the high level plateau which lies at the base of the Upland Terrace, and is covered by more recent brick-clay. It lies farther from the river and at a higher elevation than the red gravel, and there is a decided rise in the ground from the latter to the former. This terrace has been observed in many places near and in the city, but has not as yet been traced continuously, and its existence is doubtful. Nearly all the brick-yards in the city, except those in the "Neck," lie upon this gravel and back of this terrace, which lies at a mean distance of about a mile inside of the Upland Terrace. It seems as though the flood, diminishing in breadth, had eroded away the clay within this "Red Gravel Terrace." The red gravel comes to the surface, with very little overlying clay, at elevations below about 100 feet; while at a higher elevation is the brick-yard plateau.

The Pennsylvania Hospital for the Insane stands upon the hill forming this inner gravel Terrace. Its course is somewhat parallel to the main Upland Terrace, and it crosses Walnut Street near Fiftieth Street, and Broad Street near the Reading Coal Road crossing. In Prof. Rogers' Geological Map of Pennsylvania, where a rough attempt is made to represent the boundary of the drift, the line in one place corresponds quite closely with what we have presumed to be the "Red Gravel Terrace;" but it appears that in most places in that map the boundary is meant to be merely a hypothetical one. While the existence of this inner terrace is yet doubtful, and while it is probable that red gravel will be found above it and fossiliferous gravel below it, yet nothing has yet appeared to controvert the assumption that the latter gravel is older than the former. How much older, and whether of oceanic or of fresh-water origin, is not yet determined. Here, again, a study of the New Jersey gravels will be of assistance.

The Branchtown Clay.—Having now described the surface deposits lying between the Delaware River and the Upland Terrace, it remains to point out the existence of some isolated patches of gravel and clay which have been noticed on some of the hills back of and above this terrace.

In the village of Branchtown, on a plateau 250 feet above the river, there is a local deposit of brick-clay lying in an oblong belt running N. E. and S. W., perhaps a mile in length and an eighth of a mile in breadth. That it is not a clay formed in place by decomposition of the gneiss is shown by the presence in it of pebbles and rounded boulders of foreign rocks. The smaller pebbles consist of quartz, and the larger of a friable quartz sandstone, probably Potsdam. Not a single fragment of Triassic red shale, and not a single pebble of flint or fossiliferous rock was found: and in this it is distinguished from any deposit heretofore described. Nor were any of the pebbles formed of the materials of the bed of the Delaware River. Numerous sharp fragments, often six inches square, of white or yellow siliceous sandstone and of brown jaspery quartzite, both probably of lower Silurian age, were found. The peculiar conglomerate described below as "Mt. Holly Conglomerate" does not occur. Decomposed gneiss lies below the clay, which is two to three feet deep. The presence of sharp and rounded boulders of a rock in place farther north suggests an overland flood during glacial times; but the complete absence of

all traces of Triassic red shale, a formation of large extent six miles north of here, over which such a flood must have passed, is difficult to explain upon that hypothesis. This belt of clay, which may be called for convenience the "Branchtown clay," extends S. W. to Chelton Avenue and Chew Street, in Germantown, and to the N. E. to Limekiln Pike and City Line Road, and is the site of several brickyards. The clay plateau is bounded on the N. W. by a hill 325 feet high. Doubtless this clay will be found in other places, when more light will be thrown upon its origin and age.

The Bryn Mawr Gravel.—Upon the summits of some of the highest hills in the gneissic region back of Philadelphia, at a mean distance of about nine miles from the river, and at elevations of from 325 to 450 feet above it, there are isolated patches of an ancient gravel, different from any yet described, to which we have given the provisional name of "The Bryn Mawr Gravel." It can always be recognized by the presence of sharp or partially rounded fragments of a hard, heavy iron sandstone or conglomerate. Such fragments are often covered by a brownish-black iron glaze. More than ten years ago, the writer noticed in the soil of the upper part of Germantown, pieces of this conglomerate, unlike any known rock, and it is only of late that its origin has been suspected. It consists of well-rounded pebbles of quartzite or siliceous sandstone cemented by iron into a stone which is often very hard. This conglomerate is found in occasional fragments upon ground over 300 feet high, but is not found in abundance until an elevation of over 400 feet is reached. At these highest points it occurs in a red gravel whose pebbles are identical with those of the conglomerate.

One of such points is near Chestnut Hill, on the City Line Road at its highest elevation, near Willow Grove Road. Here, nearly nine miles from the river and 425 feet above it, is a patch of this gravel and conglomerate. The larger pebbles and boulders, like those of the Branchtown Clay, consist of a friable quartzite sandstone or a jaspery quartzite. Sharp fragments of quartzite are numerous; but there are no traces either of Triassic red shale, of fossiliferous pebbles, or of rounded pebbles of the underlying gneiss. It rests upon a much decomposed gneiss. The conglomerate sometimes contains cavities filled with white sand. The tract of gravel is of an oval form, whose major axis points N. E. and S. W. It crosses the Township Line Road near the Bethesda

Home, near which place have been found a sharp boulder of conglomerate three feet in diameter, several fragments of ferruginous sandstone equally large, a partially rounded boulder of white quartz nearly four feet long, and numerous fragments of quartzite and Primal rocks. The gravel is here in part replaced by clay.

A similar tract of this gravel occurs at Bryn Mawr, extending from that place to near Cooperstown. A good section is exposed in the railroad cut below the station. From this locality, so easy of access from the city, we have named the formation. It is here about 430 feet high, and nine miles from the river. The gravel is ten feet deep, and lies upon a steeply-dipping gneiss so completely decomposed that it is as soft as clay. Underneath the bridge, a soft white kaolin-like material, conformable with the gneiss, shows a decomposed steatite,—being probably the continuation of that which crosses the Schuylkill at Lafayette. Here, as at Chestnut Hill, the gravel lies in an isolated patch upon a hill, distant from any stream or other eroding agency. The gravel holds sharp fragments of primal rocks and also the iron conglomerate. As at Germantown, the fields below, to the south, contain occasional fragments of the conglomerate.

Another good exposure of the Bryn Mawr gravel is on a hill crossed by the road leading from Haverford College to Cooperstown. The conglomerate is here in large, sharp fragments, and the gravel shows slight horizontal stratification. On the crest of the hill, some 450 feet high, there is a weather-worn boulder, four feet in diameter, of a soft, coarse, brown sandstone of Bryn Mawr age, apparently in place.

A fourth, precisely similar exposure of gravel with conglomerate, and at about the same elevation, caps the hill back of Media, near the Rosetree.

Without describing any further exposures, it already appears that in these elevated patches of ancient gravel we have the last remnants of a once continuous formation. The very great erosion which has swept away all but these few traces is a sufficient proof of its age. There are no points at all approaching the elevation of these hills, between them and the Atlantic Ocean; and it is at once suggested that these patches are the remnants of an oceanic deposit, possibly of Tertiary age. It is interesting to find that a precisely similar formation caps some of the hills in New Jersey. On top of the hill at Mount Holly, N. J., is an identical con-

glomerate and gravel, similar in appearance, and composed of the same materials as the formation in Pennsylvania. The conglomerate has the peculiar ferruginous glaze already noticed. It here overlies Cretaceous marls and sands.

From its abundance at this place, and in order to show its connection with Pennsylvania deposits, we shall call the conglomerate of the Bryn Mawr gravel, "*Mt. Holly Conglomerate*." Prof. H. D. Rogers¹ suggests that this rock at Mt. Holly may be of Miocene age; but Prof. Cook, not distinguishing it from the modern iron crusts in the red Philadelphia gravel near the river, considers it very recent. In the consideration of its age it is worth noting that the sand of southern New Jersey, apparently of late Pliocene age, frequently contains rounded pebbles of Mt. Holly conglomerate, thus showing that the latter is an older formation.

From the identity of their contained boulders, it is probable that the Branchtown clay and the Bryn Mawr gravel are nearly coeval. Being oceanic, it is presumed that they will be recognized all along the gneissic hills of the southern Atlantic States.

We have given this detailed description of each of the surface formations near Philadelphia in the hope that they may be recognized elsewhere by other geologists. It has been found that a careful examination of the materials comprising each gravel, taken in connection with their elevation above tide, is the only means of discriminating between them. Desultory observations in detached localities are of little value. Should this work be extended in Pennsylvania and New Jersey, and the distinctions between the four gravels described be carried out, it is thought that, notwithstanding the shifting character of the underlying strata in the latter State, much may be done not only towards an exact determination of their age, but towards a settlement of some of the vexed problems of surface geology in Eastern America.

Recapitulation.—The results obtained may be briefly summarized as follows:—

Forming the N. W. boundary of the Philadelphia gravel and brick-clay is a hill of gneiss, rising 200 feet or more above the river, which may be called the Upland Terrace. It has a N. E. and S. W. trend, and in this vicinity is at an average distance of five miles from the river.

¹ Report on the Geology of N. J., 1839.

Within the Upland Terrace, resting upon its slope, and extending to the river, is a series of stratified gravels and a boulder-bearing brick-clay. Of these, the oldest is the "Fossiliferous gravel;" a gravel lying near the terrace and under the brick-clay, and containing pebbles which frequently are fossiliferous. Of more recent age, and at a lower level, is the "Philadelphia red gravel," which is made up of the pebbles of the Fossiliferous gravel mixed with fragments of Triassic red shale and other rocks brought down the Delaware Valley. It is distinctly stratified, rests upon decomposed gneiss, and contains rounded boulders dropped by floating ice. Upon both of these gravels rests the Philadelphia brick-clay, often lying unconformably upon them in a series of pot-holes or wave-like forms, and apparently an aqueous deposit.

A yet more recent formation, the "River gravel and sand," lies within the others and close to the river, and is made up of flattened pebbles composed of the rocks over which the river flows. Upon this, in the river flats, lies a modern mud, the "Recent Alluvium."

Back of the Upland Terrace, isolated patches of two surface deposits, more ancient than any yet described, lie upon the hills. These are, the "Branchtown clay," at a height of 250 feet, containing boulders of Potsdam rocks, but no traces of Triassic red shale or of fossiliferous pebbles; and the "Bryn Mawr gravel," which caps hills of a higher elevation, and which, containing boulders and pebbles of identical material with those of the last, is characterized by the presence of a hard iron conglomerate or sandstone. This conglomerate, occurring also in New Jersey, and named the "Mt. Holly Conglomerate," is conjectured to be of Tertiary age.

In these seven formations is written the geologic history of the Delaware Valley.

Much remains to be done before any certain results can be expected. It is hoped that the imperfect examination here recorded may form the basis for a future and more thorough study, which, extending to wider fields, shall make more exact the knowledge of our surface geology.